A Global Modeling Initiative (GMI) Study:

The long-range, cross-tropopause transport of CO

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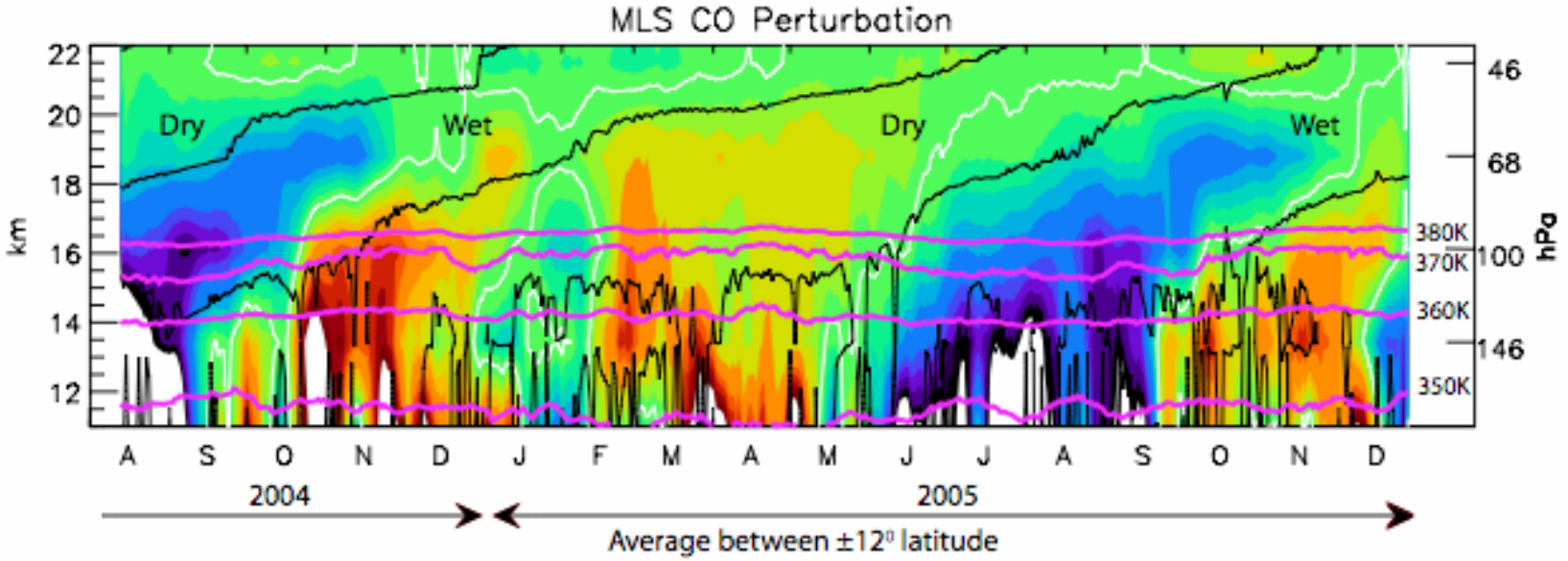
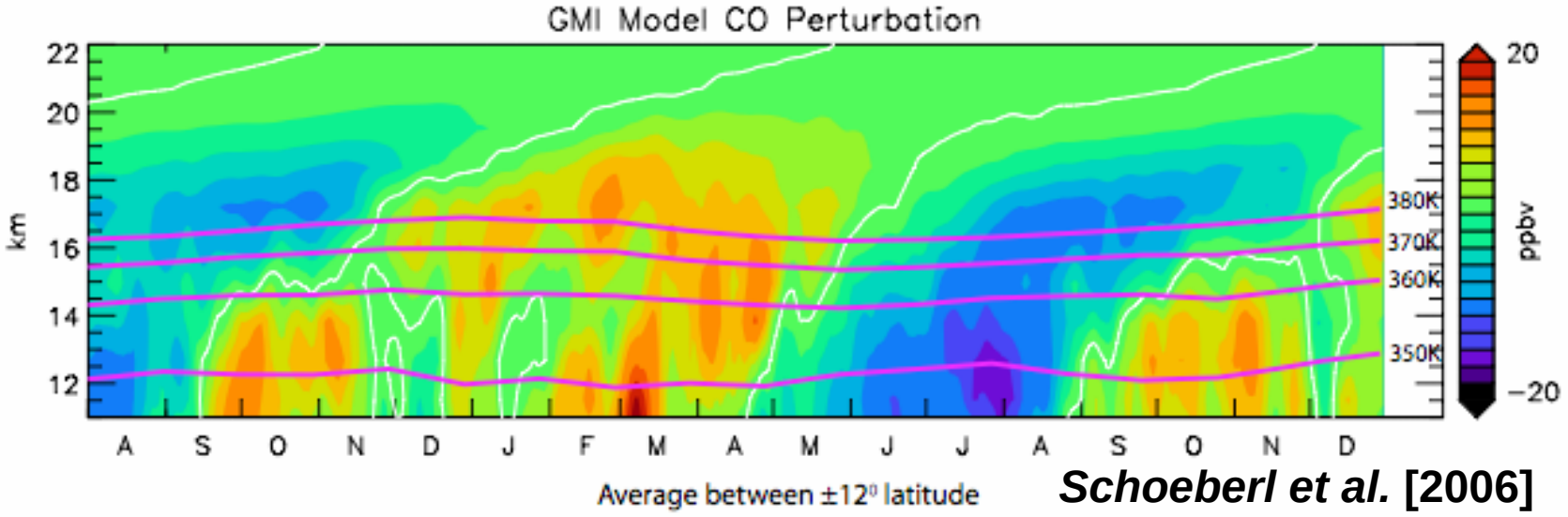
Inspiration ⇒ *CO "Tape Recorder" in Aura MLS*



Driven by Seasonal Biomass Burning and Convection.

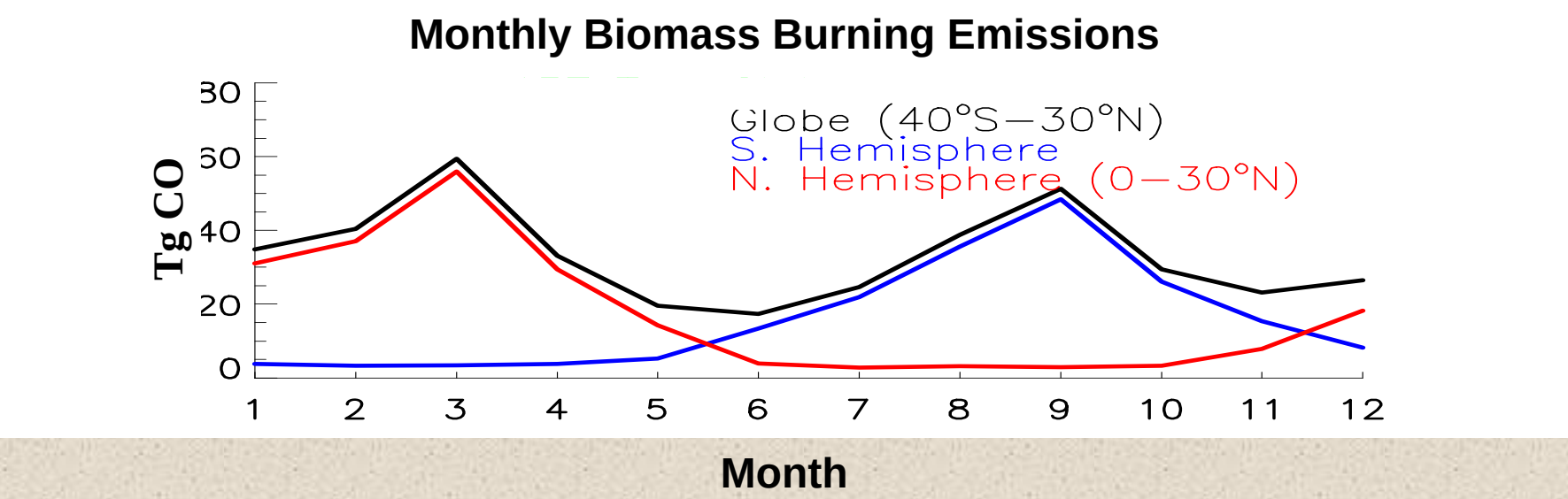


***Schoeberl et al.* [2006]**

CO Tape Recorder Driven by Seasonal Biomass Burning

⇒ **Fires set to clear agricultural fields/pastures before seasonal rains.**

⇒ **Seasonal convection lofts pollution to the upper troposphere.**



But, why should anyone care about the CO tape recorder?

Biomass burning isn't a source of key players in the stratosphere, right?

Because the pollutants may impact:

- **Lifetimes of Trace Gases in Tropical Tropopause Layer (TTL)***

  CO, NMHC, etc. + OH

  ***Air in TTL resides several weeks before crossing the tropopause.**

- **Radiation Budget – Dynamics in TTL**

  ozone and aerosols - troposphere-to-stratosphere (TST) exchange

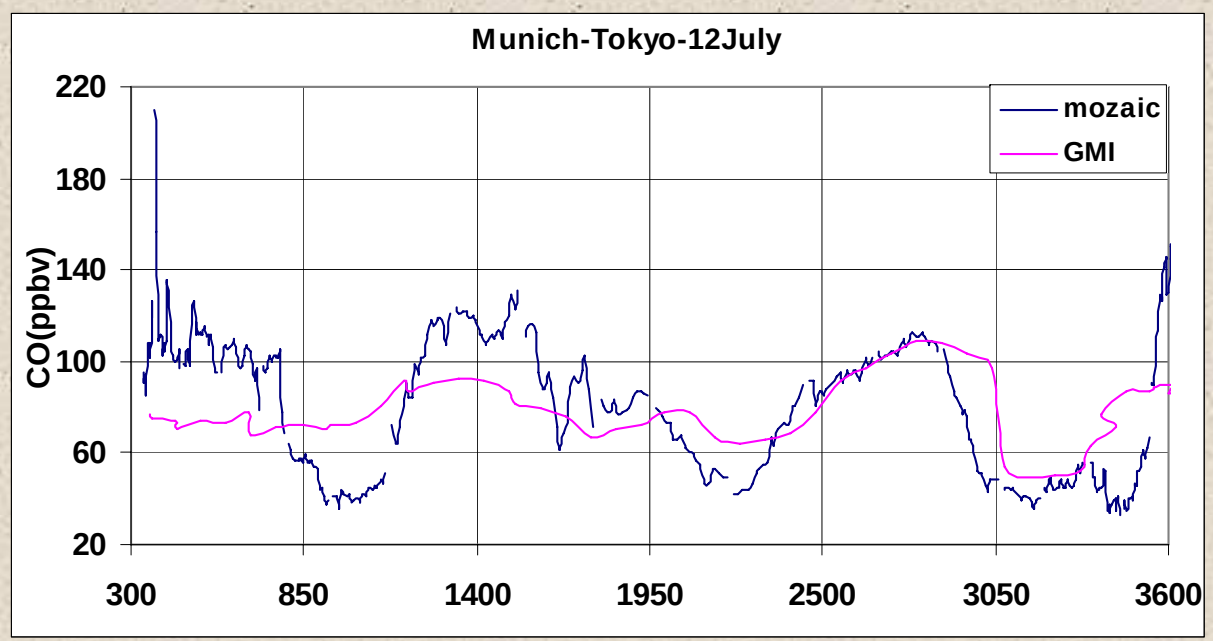
Model Comparison to MOZAIC Aircraft Data in Upper Troposphere

Cruise Altitude: 9-12 km

Japan Airlines Data

W. Pacific 40-130 ppbv
1997 Indonesia <400 ppbv

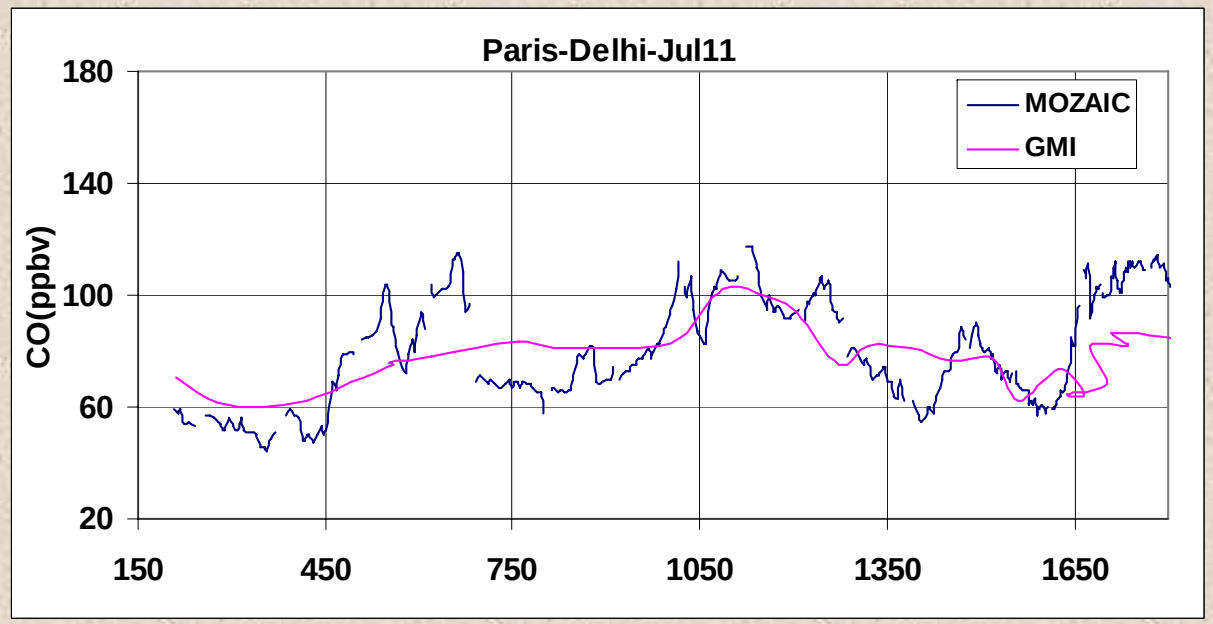
Matsueda et al. **[1998,1999]**



MOZAIC Aircraft Data

Europe 50-140 ppbv
Asia <150 ppbv
Boreal BB >500 ppbv

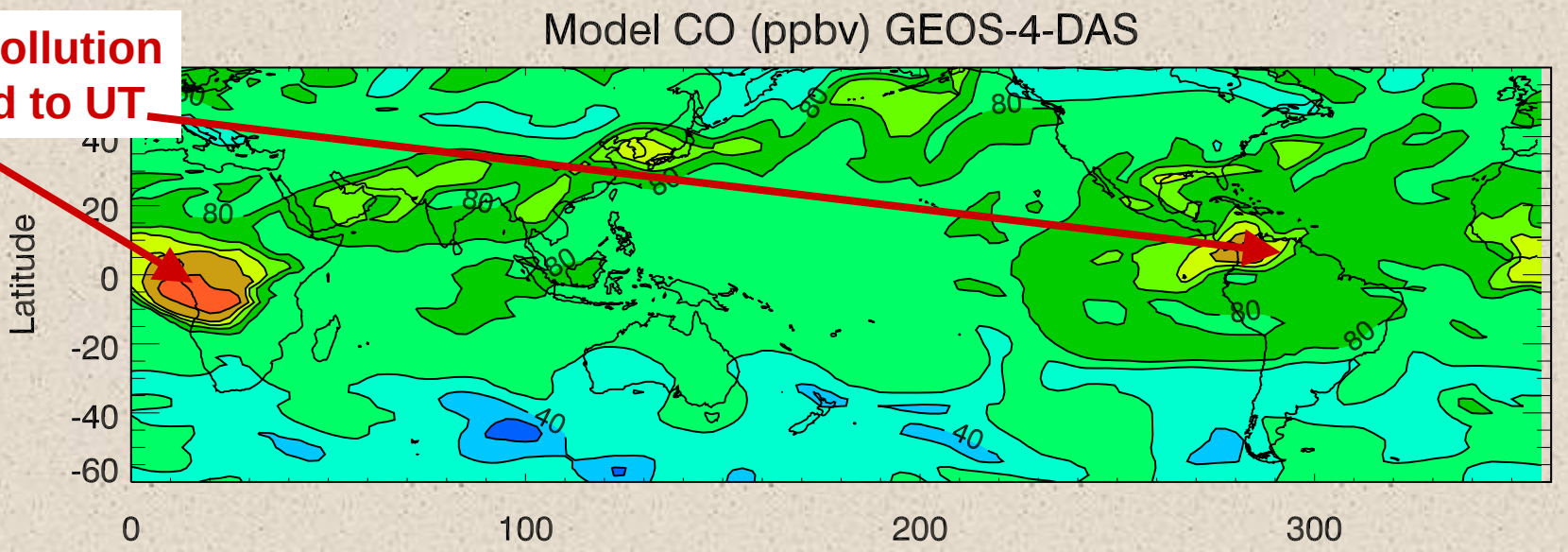
Nedelec et al. **[2005]**



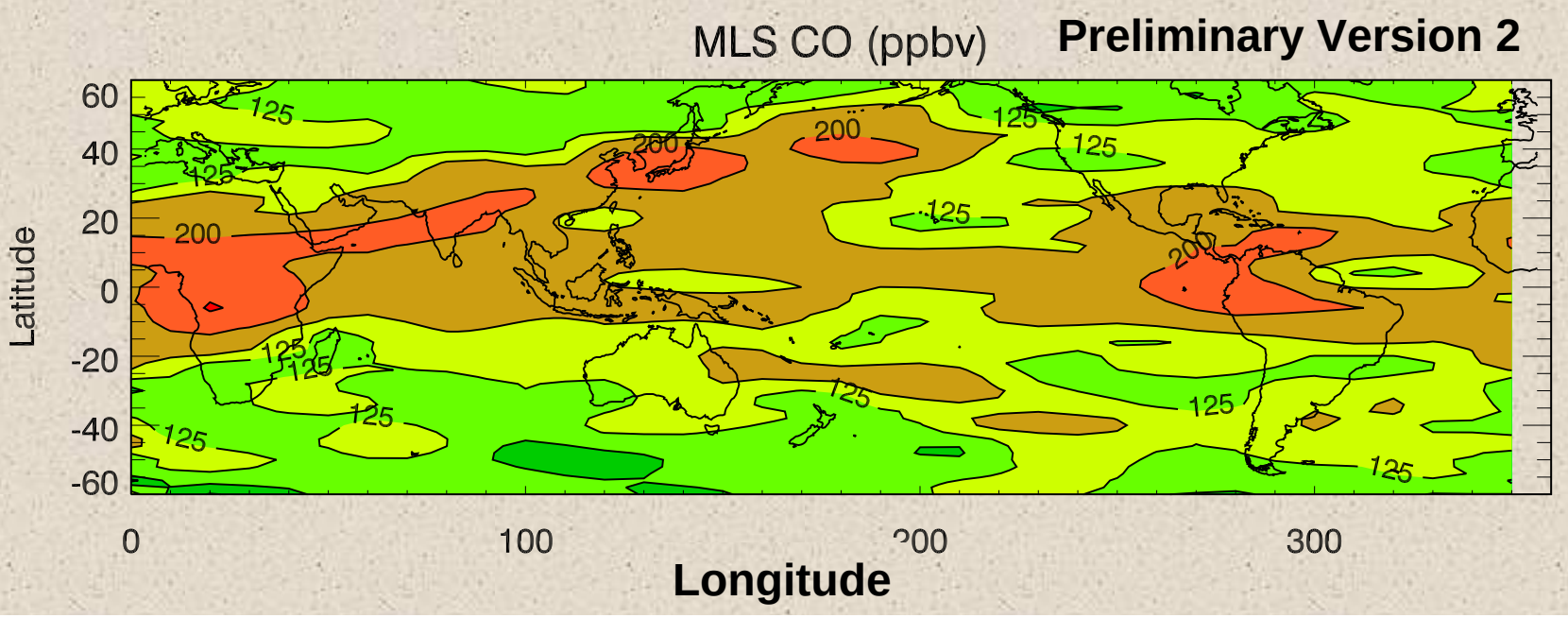
***Joanna to show more!**

215 hPa : September 21, 2005

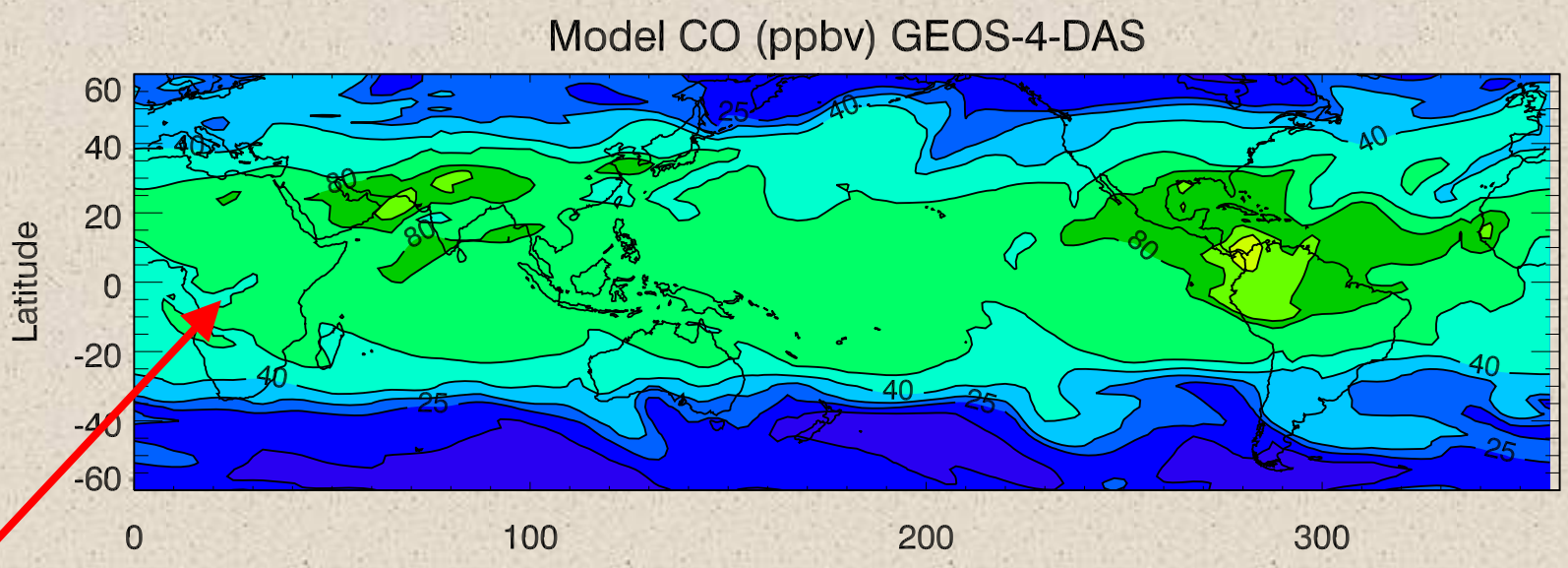
BB pollution lofted to UT



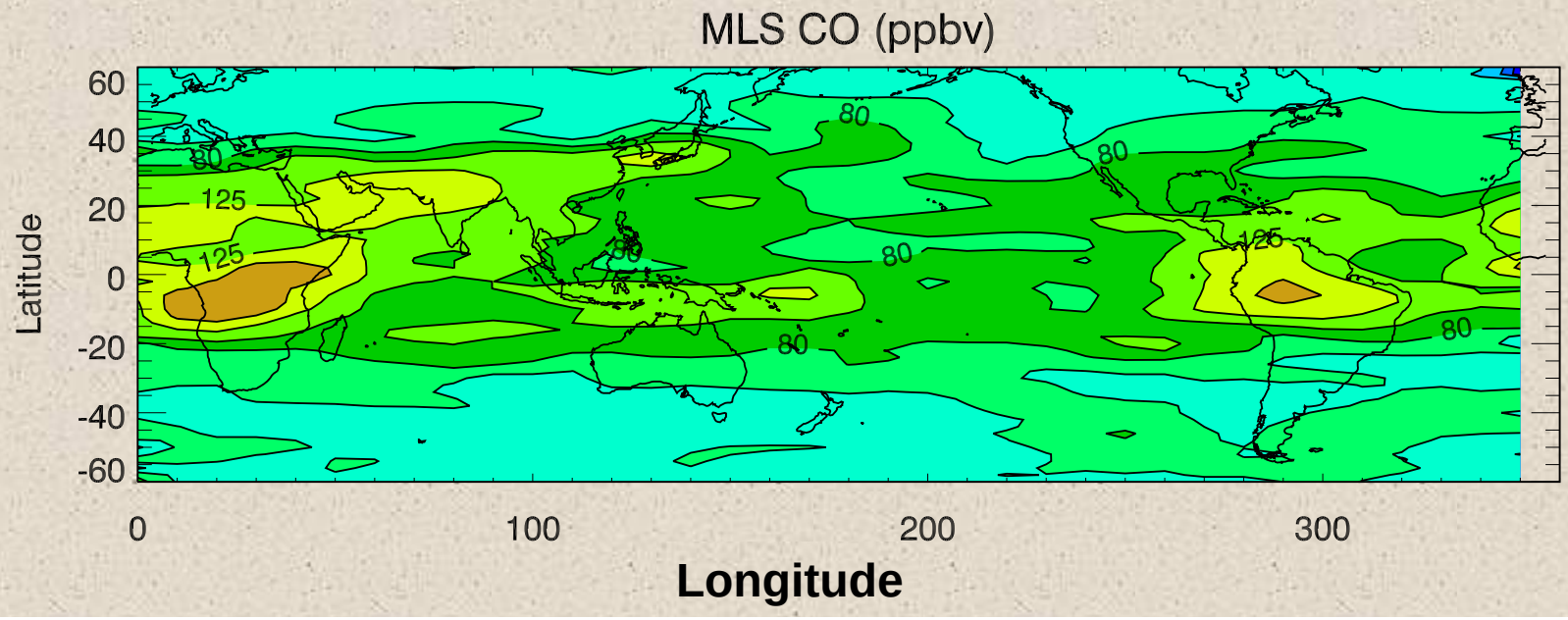
Note: DAS fields = excessive tropical convection : MLS has water vapor issues.



146 hPa : September 21, 2005



Height of convection too low? Averaging kernals?



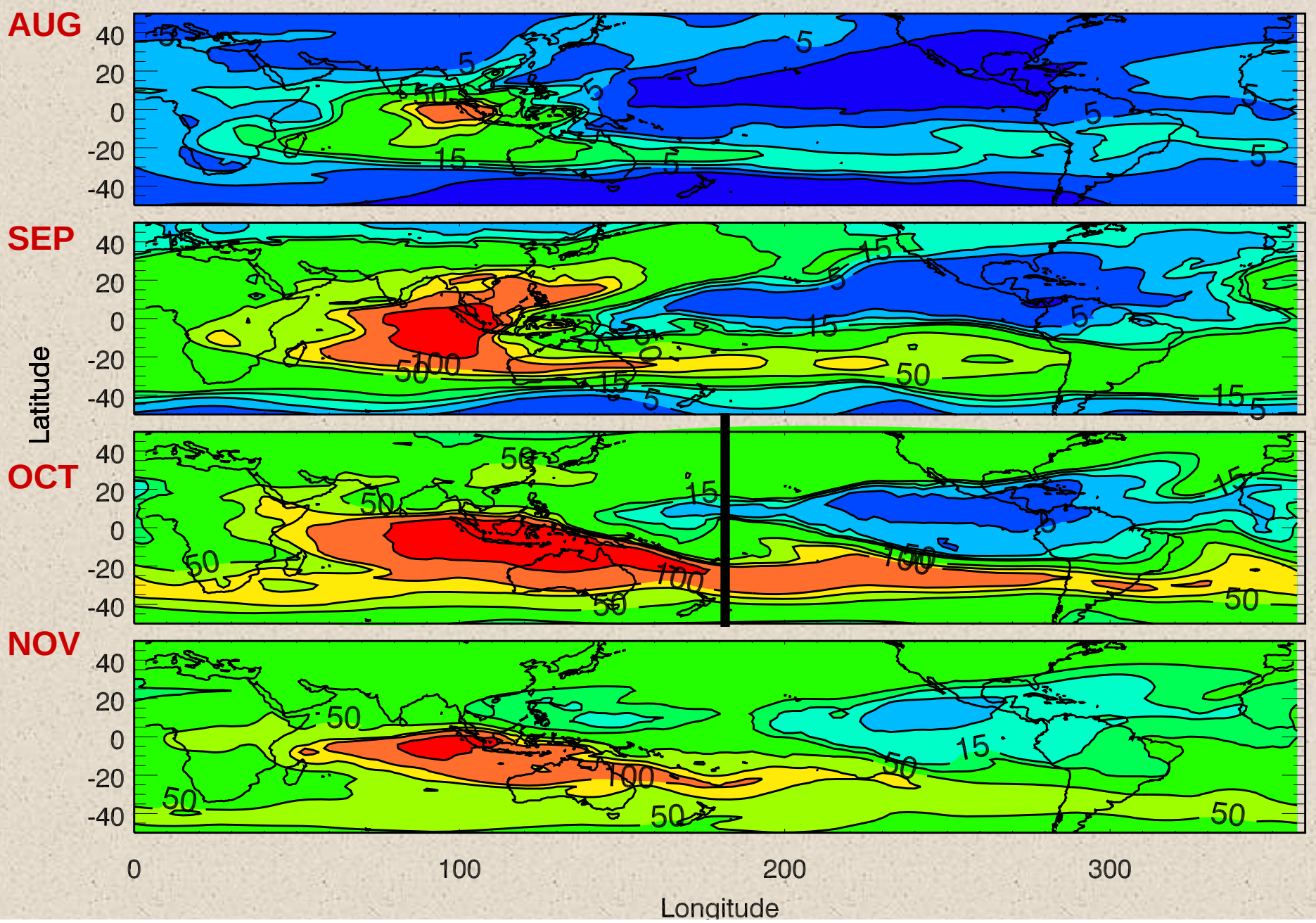
⇒ Summary of MLS CO vs GMI CO Comparison

- *Spatial distributions of MLS CO similar to model, though biased high.*
- *But only few days of data so far.*
- *Both model and observational limitations.*

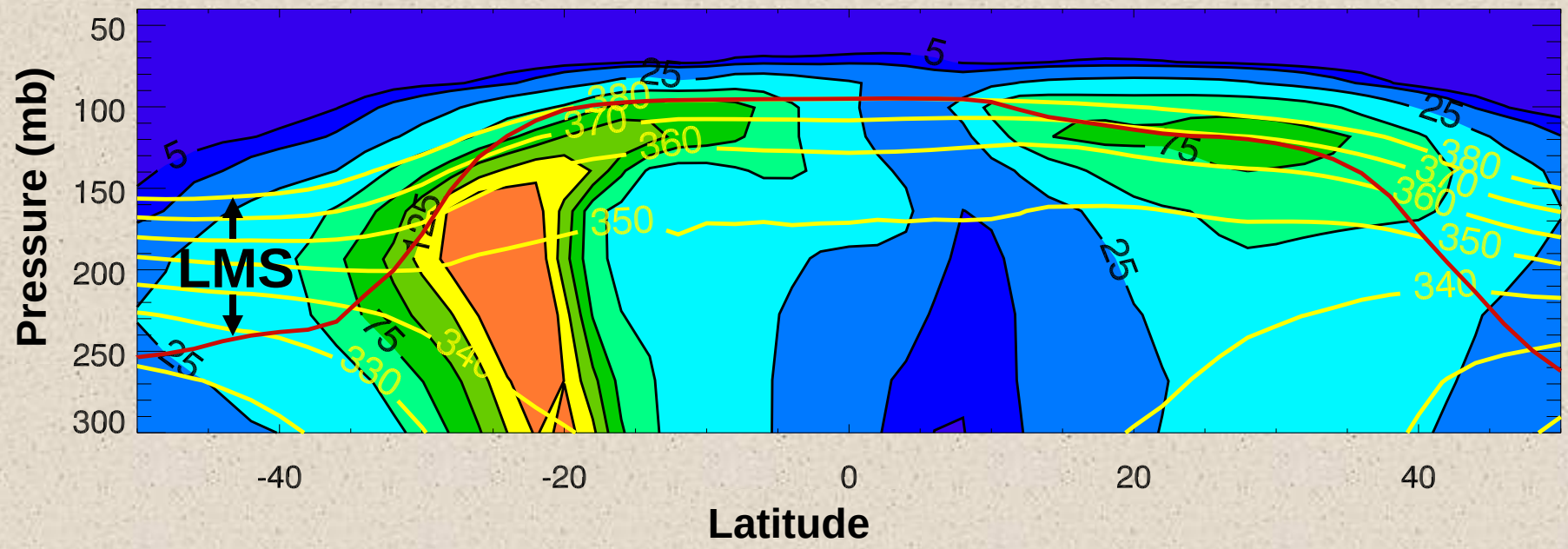
⇒ Application of MLS CO Data in UT/LS

- *Transport of BB pollution to/in UT/LS*
- *BB causes much of the variation in CO in UT/LS*

Indonesian Fires 1997: CO Perturbation (%) ~200 mb



October 1997 : CO Perturbation (%)
180° Longitude



Yellow Lines = Isentropes **Red Line = Approximate Tropopause**

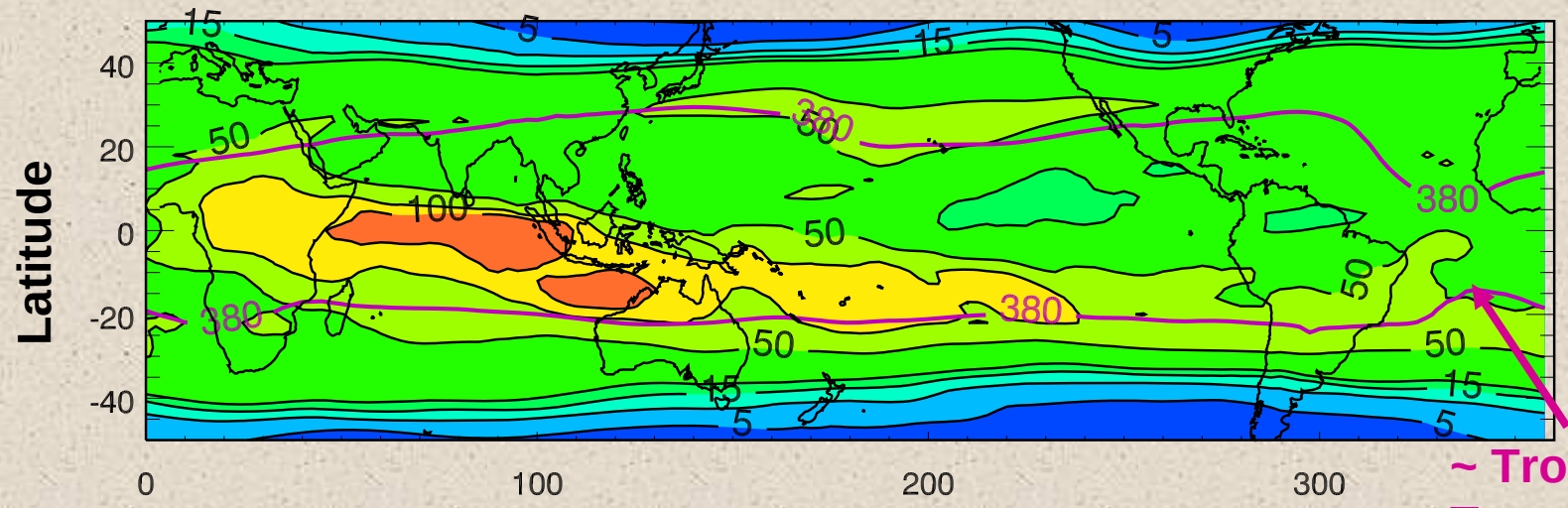
⇒**Troposphere-to-Stratosphere Exchange (TST) via Quasi-horizontal, Quasi-isentropic Exchange**

⇒ **But, pollution in Lowermost Stratosphere (LMS) returns to troposphere eventually**

November 1997: CO Perturbation (%)

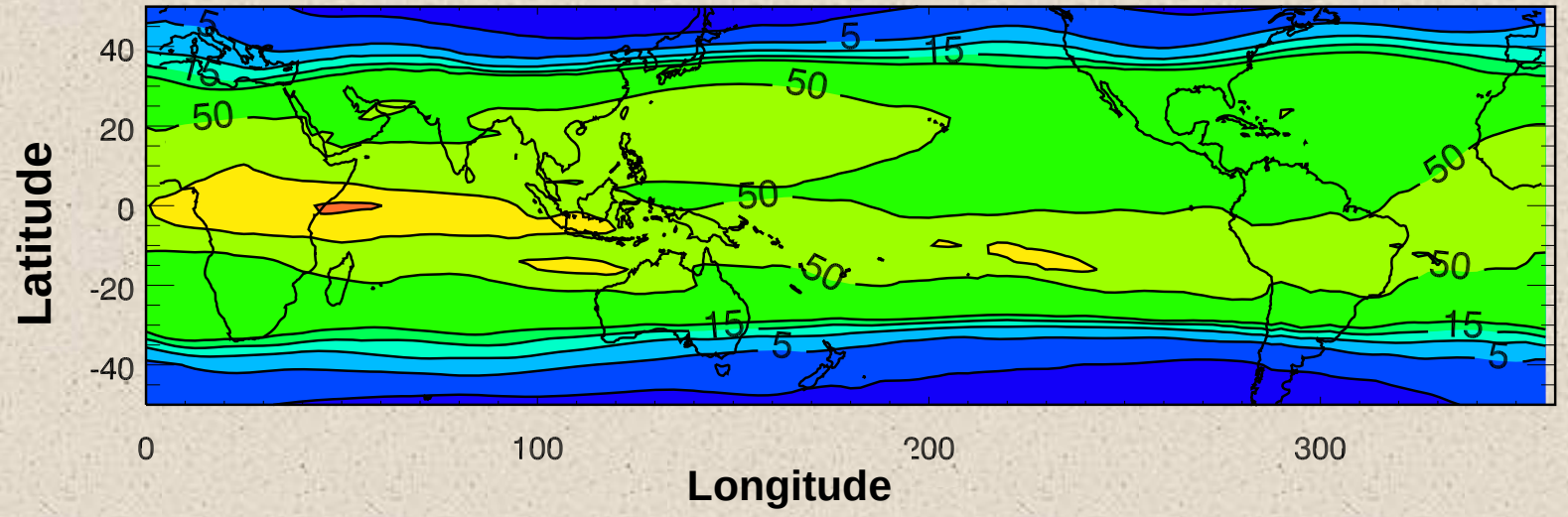
⇒ **TST via Slow Ascent in TTL**

~100 mb – Near Tropical Tropopause

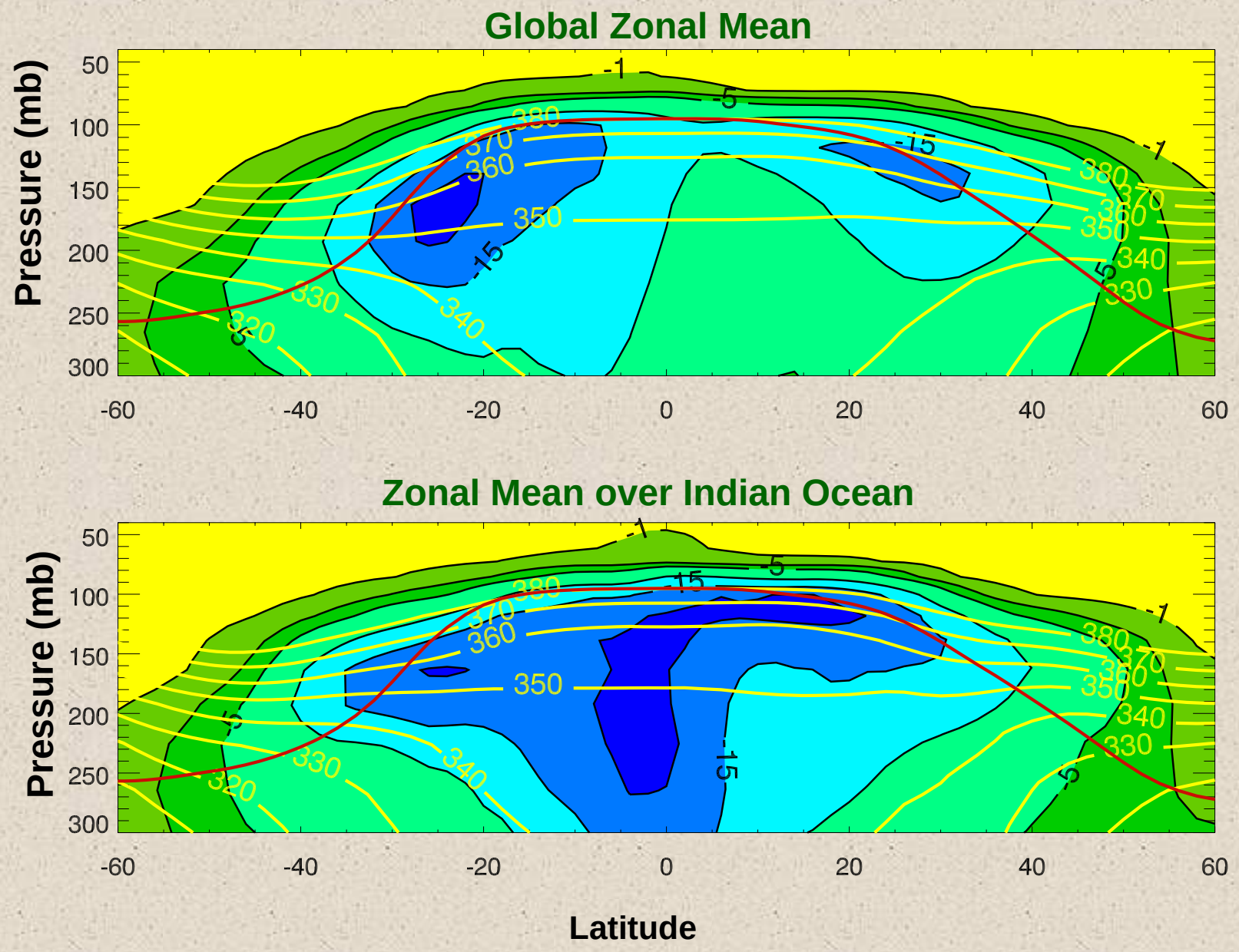


~ Tropical Tropopause

~80 mb – Lower Stratosphere

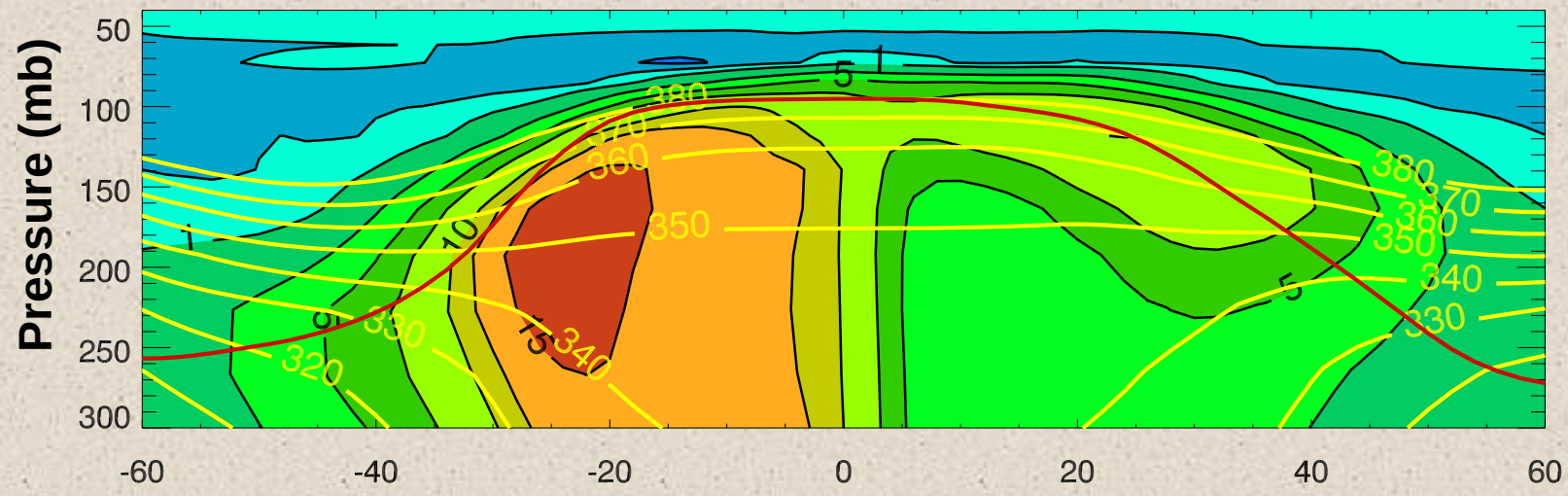


October 1997: OH Perturbation (%)



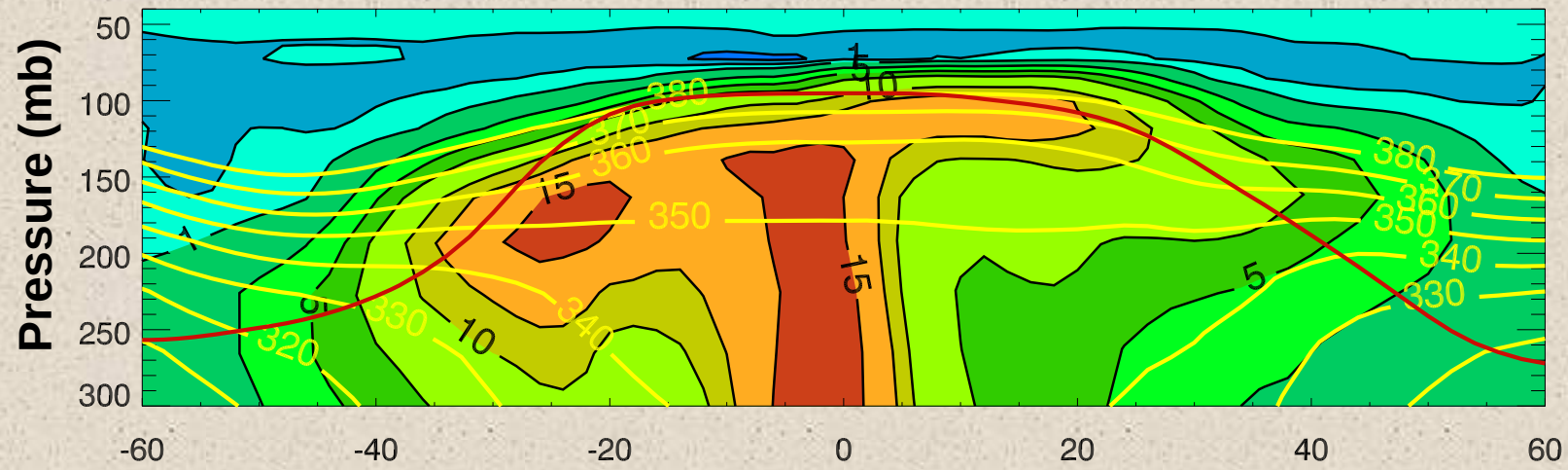
October 1997: Ozone Perturbation (ppbv)

Global Zonal Mean



Locally: 25-100% increase over Maritime Continent!

Zonal Mean over Indian Ocean



Impact by Region (fvgcm 1994-1996 SSTs)

⇒**1994-1996 : weak ENSO phases**

⇒ **Climatological BB Emissions (Tg CO/y)**

southern Africa	**= 86**
northern Africa	**= 87**
South America	**= 60**
Southeast Asia	**= 82**

⇒ **These two pathways common for more typical burning events too.**

⇒ **Plumes of S. America and southern Africa mingle, though plume from S. America has bigger impact on [CO] in UT/LS due to deeper convection.**

⇒ **ENSO Effects***

Indonesia

Central America & Mexico

**IAV in emissions dominates over IAV of transport.*

⇒**IAV transport mainly due to IAV of convection (<30%).**

Conclusions

- **CO Comparison: MLS & GMI Combo**

  ⇒ *Very encouraging.*

  ⇒ *Can we see evidence of biomass burning transport in UT?*

  - *Only a few days of data.*
  - *Vertical resolution adequate?*

- **Big tropical burning event:**

  ⇒ *TST of pollution via:*

  - *slow ascent in TTL.*
  - *exchange in subtropical jets.*

  ⇒ *Impact on trace gases in TTL substantial.*

  - *Did pollution impact dynamics of TTL?*

    Aerosols: shortwave radiative forcing at surface = -10 W/m^2 over Indian Ocean and -150 W/m^2 over Indonesia! (Need to calculate heating rates!)

  ⇒ *Driven by El Niño-induced drought & human activities.*

  ∴ 1997 scenario likely to repeat in future.

Unresolved Issues

- **2004-2005 Aura Period Emissions**
  - ⇒ ***Fossil Fuel – E. Asia 2003, but Rest of World?***
  - ⇒ ***Biomass Burning – GFED2***
  - ⇒ ***Biofuels ?***
  - ⇒ ***Lightning Emissions***

- **Too Low Tropospheric CO**

Surface CO
Combo (1994) vs GMD (1992-1996)

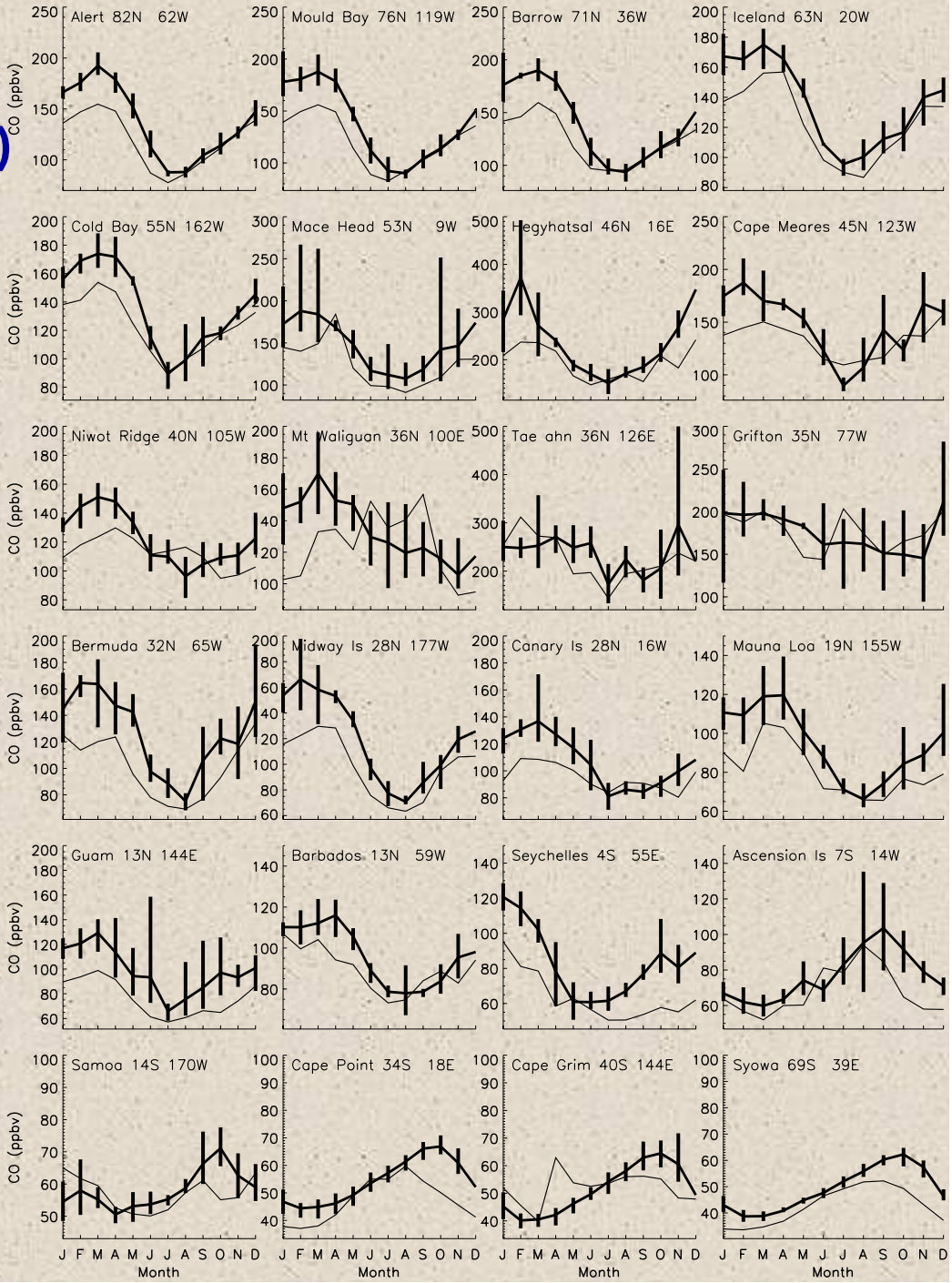
Model is biased low when long-range transport is important globally.

Model generally has no bias when photochemical production is dominant.

Methylchloroform lifetime reasonable 6.1 y (6.7 / 5.7 y in SH / NH)

Emissions?

***Accounts for missing NMHC.**



Biomass Burning by Region